
Living With a Star (LWS) Program

GUIDELINES AND CRITERIA FOR THE
Geospace-Related Missions of Opportunity
PHASE A CONCEPT STUDY

As amended: February 23, 2007

Amendments

Amendment 1: Appendix B, Guidance for Balloon Missions, Evaluation Criteria for the Safety, Reliability, and Quality Assurance has been added. (February 23, 2007)

Amendment 2: References to NASA NPR 7120.5C have been changed to reference NASA NPR 7120.5D. (February 23, 2007)

GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY

INTRODUCTION

The Geospace-Related Missions of Opportunity (GR-MOO) proposals submitted to the Radiation Belt Storm Probes Investigations and Geospace-Related Missions of Opportunity Announcement of Opportunity NNH05ZDA003O (AO) that were selected for a competitive Phase A study will conduct a concept study to better define the investigation, its implementation requirements (both engineering and management), and its risks. Upon completion of the concept study, proposers (also referred as investigation teams from hereon) will submit a Concept Study Report (CSR) for NASA evaluation. Subsequently, as part of the NASA evaluation, there will be a site visit by NASA evaluators. The full evaluation will allow NASA to decide which investigations will continue to Phase B. In this “Guidelines and Criteria for the Geospace-Related Missions of Opportunity Phase A Concept Study” (referred as the Guidelines from hereon) document, Part I discusses the criteria to be used by NASA for the evaluation of the CSR, Part II provides guidance for preparation of the CSR’s, Appendix A contains definitions of cost element terms used in the cost plan section, and Appendix B provides the guidance for balloon missions on the criteria for safety, reliability, and quality assurance.

Concept Study Report (CSR)

The CSR is to be a self-contained document; investigation teams must not assume that NASA evaluators will have reviewed or even have access to the original Step 1 proposal.

The concept study will constitute the investigation’s development of the baseline mission concept (Phase A) as outlined in NPR 7120.5D, NASA Space Flight Program and Project Management Processes and Requirements.

Please note that all program constraints, guidelines, definitions, and requirements given in the AO are still valid for the CSR except as noted herein.

The CSR is due by 4:00 PM Eastern time, **September 12, 2007**, at

LWS Geospace-Related Mission of Opportunity
Science Mission Directorate
NASA Research and Education Support Services (NRESS)
500 E Street, SW, Suite 200
Washington, DC 20024
Tel: 202-479-9030

Site Visits

The NASA evaluators will conduct a site visit to the proposers for clarification of any aspects of the CSR. The timing of these site visits will be several weeks after the CSRs are due and will be

approximately one day in length. The specific date of the site visit will be set with at least three months advance notice.

PART I - EVALUATION CRITERIA

The NASA evaluation of the CSRs will be similar to the evaluation of the original Step 1 proposals as discussed in Section 7.0 of the AO. However, in addition to considering any changes to the science objectives from those in the original Step 1 proposal, this evaluation will consider *in detail* all factors related to the probability of investigation success and to the realism of the proposed costs to NASA. Education and Public Outreach (E/PO) is not an evaluation factor.

Successful implementation of the GR-MOO investigations demands, in addition to scientific merit, that the investigation be achievable within the established constraints on cost and schedule. The information requested in Part II of this document will enable the evaluation panel to determine how well each investigation team understands the complexity of its proposed investigation, its technical risks, and that weaknesses have been retired or will be effectively addressed during Phase B. For missions of opportunity proposing suborbital flight on high altitude balloons, Appendix B of this document defines evaluation criteria for Safety, Reliability, and Quality Assurance.

The criteria for evaluating the Phase A concept study are as follows:

- a. Scientific merit.
- b. Scientific Implementation merit, including Technical Merit.
- c. Technical, Management, and Cost (TMC) feasibility, including cost risk

Scientific Merit and Scientific Implementation Merit, Including Technical Merit

The first two criteria are the same as described in Section 7.2 of the AO. The science objectives must not change from those in the original Step 1 proposal. Any changes to science implementation will be carefully evaluated. If there are no substantive changes in the science implementation, then the scientific merit of the proposed investigation (first criterion) and the scientific implementation merit of the proposed investigation (second criterion) will not be reevaluated. In this case, the results from evaluations of scientific merit and of scientific implementation merit of the original proposal will be retained.

Assuming that there are no changes to the proposed science or its implementation, the emphasis of the evaluation will be on the Technical, Management, and Cost (TMC) feasibility, including cost risk, of the proposed investigation (third criterion).

Technical, Management and Cost (TMC)

The information requested in Part II of this document will be used to evaluate each investigation in detail for the feasibility of investigation implementation as reflected in the perceived risk of accomplishing the investigation within proposed resources. The TMC criteria in the AO will be supplemented with the following considerations:

The technical and management approaches will be evaluated to assess the likelihood that the investigation can be implemented as proposed. This will include an assessment of the risk of completing the investigation within the proposed cost. It will also consider the adequacy of the proposed approach, the organizational structure, the roles, relevant experience and past performance of the proposer and partners, the management approach, the commitments of partners and contributors, and the investigation team's understanding of the scope of work (covering all elements of the investigation, including contributions). The experience and expertise of the development organizations will be factors in assessing the probability of success. The relationship of the work to the project schedule, the project element interdependencies, and associated schedule margins will also be evaluated. The proposal must discuss the methods and rationale (cost models, cost estimating relationships of analogous investigations, etc.) used to develop and validate the estimated cost and must include a discussion of cost risks. Innovative cost effective features, processes, or approaches will be rewarded if proven sound.

The evaluation will consider the proposer's understanding of the processes, products, and activities required to accomplish development of all elements (e.g., multiple instruments, ground and data systems, etc.), the integration of all elements, and the adequacy of the proposed approach including reserves and margins. The technical approach will be examined in its entirety to ensure that: (1) all elements and processes are addressed, (2) weaknesses and design issues are understood and plans for resolution have been identified, (3) fundamental design trades have been identified and studies planned, and (4) primary performance parameters have been identified and minimum thresholds established. Government Furnished Equipment (GFE) will be assessed to verify that it is being used within its intended capability. The overall approach (including schedule), the specific design concepts, and the identified hardware/software will be evaluated for soundness, achievability, and maturity. Resiliency and design performance margins will also be factors in this evaluation. The investigation's use of new technology will be assessed. When new technology and/or systems are proposed, proposers must provide detail development plans to achieve Technology Readiness Level (TRL) 6 by the end of Phase B (see TRL definition chart provided in the Radiation Belt Storm Probes (RBSP) AO library (<http://sso.larc.nasa.gov/rbsp/rbsplib.html>)). Investigations proposing new technology, i.e., technologies having a TRL less than 6 will be assessed a higher risk rating if adequate backup plans to ensure success of the investigation are not described.

The credibility and realism of the cost estimates and the planned financial resiliency will be evaluated. The underlying rationales for the cost estimates, including adequate reserves (see AO Section 1.4.), will be factors in this evaluation. The proposed investigation cost risk will be evaluated against the \$47M in real year dollars available for Phases A-E of the Living With a Star (LWS) GR-MOO.

All investigations must include adequate reserves at every phase of the mission. In particular, investigations must plan to maintain a reserve through the end of Phase B of at least 25 percent of *all costs* to be expended through to the end of Phase D.

The information provided in the Management section must demonstrate the proposer's plans, processes, tools, and organization for managing and controlling the development and operations

of the investigation, including performance measurement and reporting. The soundness and completeness of the approach and the probability that the investigation management team can assure mission success will be evaluated by reviewing the organizational structure (including roles, responsibilities, accountability, and decision making process) and the processes, plans, and strategies the team will use to manage the various investigation elements through all phases of the mission. Factors in this evaluation will include: clear lines of authority, clean interfaces, prudent scheduling and cost control mechanisms (including reserves), review processes, and demonstrated awareness of all necessary management processes. Risk management activities plans and budget are also factored into this evaluation. Additional factors in the evaluation of the probability of investigation success will include the experience, expertise, and commitment of key personnel and their organizations, the adequacy of facilities and equipment proposed for the mission, the investigation team's approach to risk management, and the adequacy of the management and control mechanism. Innovative management processes and plans will be rewarded if proven sound.

The completeness of the Phase B plans will be considered in determining the adequacy of the Phase B approach. This will include an evaluation of the activities/products, the organizations responsible for those activities/products, and the schedule (including reserves) to accomplish the activities/products.

PART II - REQUIRED QUANTITIES, MEDIA, FORMAT, AND CONTENT

The signed original, forty (40) paper copies of the CSR, and an additional twenty-five (25) copies of the Fact Sheet are required. It is required that each paper copy of the CSR be accompanied by a CD containing an electronic PDF format version of the CSR in a single file. The PDF document must be searchable and bookmarks must be used to outline major sections of the document. Proposers must also submit the data in cost tables as separate files on the CD. Each of these cost tables, including the headings for the rows and columns, must be in a tab-delimited text file. Optionally, versions of these files in Excel can also be included. Each CD that will accompany the original or a copy of the CSR must include the required files. *These CD's and the files must be readable with both PC and Mac computers.* The required uniform format and contents are summarized below. Failure to follow this outline may result in reduced ratings during the evaluation process.

If beneficial to the understanding of potential data products or mission operation concepts, the CD may include up to four (4) simple simulations, e.g. QuickTime movies, that are referenced and described in the CSR. Other than these simulations, do not include any other information on the CD that is not included in the paper volumes of the CSR.

When *changes* have been made to any data provided with the original proposal as a result of the concept study, *they must be clearly identified.* The content of the CSR is discussed in the subsequent paragraphs. *Note that all program constraints, guidelines, requirements, and definitions given in the AO are still valid for the CSR except as noted herein.*

The CSR shall contain no more than 114 pages (plus 8 pages per additional instrument for instrument suites), covering Sections B-I of these Guidelines, including no more than seven foldout pages (28 x 43 cm; i.e., 11 x 17 inches). Three-ring binders may be used. Note that;

- A foldout page counts as one page
- All pages other than foldout pages shall be 8.5 x 11 inches
- Single- or double-column format is acceptable.
- In complying with the page limit, no page may contain more than 55 lines of text
- The type font must not be smaller than 11-point except within figures and tables, where the type font must not be smaller than 9-point.

The following page limits apply:

Section	Page Limit
A. Cover Page and Investigation Summary	No page limit, but be concise
B. Table of Contents	2
C. Fact Sheet	2
D. Executive Summary	5
E. Science Investigation (changes highlighted)	30, plus 8 pages per additional instrument if a suite of instruments is proposed)
F. Technical Approach and Mission Design G. Management Plan H. Education and Public Outreach (E/PO) and Small Disadvantage Business Plan I. Technical Definition (Phase B) Plan	75
J. Cost Plan	No page limit, but data must be presented in formats described; be brief
K. Appendices (No other appendices permitted) 1. Letters of Endorsement 2. Relevant Experience and Past Performance 3. Resumes 4. Statement(s) of Work for Each Contract Option 5. Data Management Plan 6. Any Incentive Plan(s) 7. Any NASA PI Proposing Team 8. Technical Content of Any International Agreements 9. Discussion on Compliance with U.S. Export Laws and Regulations – Update from Proposal 10. Science Level 1 Requirement 11. Acronyms List 12. Reference List (Optional)	No page limit, but brevity highly encouraged

A. COVER PAGE AND INVESTIGATION SUMMARY

A Cover Page and Investigation Summary must be a part of the CSR, but will not be counted against the page limit. It must be signed by the Principal Investigator (PI) and an official of the PI's organization who is authorized to commit the organization. Create a custom cover page, which contains the following information. The full names of the PI and the authorizing official, their addresses with zip code, telephone and fax numbers, and electronic mail addresses, are required, as well as the names, institutions, and E-mail addresses of all participants, the type of investigation proposed, the total NASA's Science Mission Directorate (SMD) Cost, and a 200-word Summary. A hard copy version of this Cover must be printed in time to acquire signatures and include with the original hard copy of the CSR.

B. TABLE OF CONTENTS

The CSR shall contain a table of contents that parallels the outline provided in Sections C through J below.

C. FACT SHEET

A Fact Sheet that provides a brief summary of the proposed investigation must be included. The information conveyed on the Fact Sheet must include the following: science objectives (including the relevance of the science to the NASA Heliophysics Division), investigation overview (including investigation objectives and major mission characteristics), science payload, investigation management (including teaming arrangement as known), schedule, and cost estimate. Other relevant information, including figures or drawings, may be included at the proposer's discretion. The Fact Sheet is restricted to two (2) pages (preferably a double-sided single sheet).

D. EXECUTIVE SUMMARY

The Executive Summary is to be a summary of the contents of the CSR and is to include an overview of the proposed baseline investigation including its scientific objectives, the technical approach, management plan, cost estimate, and small disadvantaged business plans. The Executive Summary must not exceed five (5) pages in length.

E. SCIENCE INVESTIGATION

This section shall describe the science investigation resulting from the concept study. Any descoping of, or changes to, the investigation from the "Proposed" and "Minimum Science" defined in the original Step 1 proposal must be identified and the rationale for the change(s) given. Changes may be highlighted in bold with column marking for easy identification and must be provided in a change matrix giving the original (proposed) requirement, the new requirement, rationale for the change, and its location within the CSR. If there are no changes, this section must be repeated identically from the proposal with a statement that there are no changes.

Special attention must be given to assuring that both the planning and resources are adequate to analyze, interpret, process, and archive all the data produced by the investigation in the appropriate data archive. Resources include cost, schedule, and work-hours for scientific interpretation of results and publication.

It is expected that modifications will be required in the description of the science implementation, especially as relates to the criterion for feasibility. A page quota larger than that in the original Step 1 proposal has been allotted for this purpose.

F. TECHNICAL APPROACH AND MISSION DESIGN

The Technical Approach section must detail the method and procedures for investigation definition, design, development, testing, integration, ground operations, and flight operations. A discussion of all new/advanced technologies planned for the investigation must be provided and include backup plans with scheduled decision criteria if those technologies cannot be ready. This section must also detail the expected products and end items associated with each phase. Investigation teams have the freedom to use their own processes, procedures, and methods. The use of innovative processes, techniques, and activities by investigation teams in accomplishing their objectives is encouraged when cost, schedule, technical improvements, and risk containment can be demonstrated. The benefits and risks, if any, of any such processes and products must be discussed. This section must be complete in itself without the need to request additional data, although duplications may be avoided by reference to other sections of the CSR if necessary.

1. Technical Approach Overview. This section must provide a brief overview of the technical approach including its key challenges.
2. Science Payload. This section must describe the science payload for the investigation in detail. Highlight any changes to the payload or individual instruments or their performance since submission of the proposal. A clear plan for the accommodation of the instrument(s) on the host vehicle must also be included. Subsystem characteristics and requirements must be described. Such characteristics include: mass, volume, and power requirements; pointing requirements; new developments needed; and a space qualification plan. Include where appropriate: block diagrams; lower-level mass breakouts listing major components (master equipment list, see sample on Figure 8.); physical layouts; calibration plans (before and/or during operations); operational and control considerations; and software development. Any design features incorporated to effect cost savings must be identified. A summary of the resource elements of the instrument design concept, including key margins, must be provided. The rationale for margin allocation must be provided. Those design margins that are driving costs must be identified. The CSR may reference Section E to avoid duplication. Discussions of the plans for new technology development and back-up alternatives must be discussed. NASA's SMD requires that all technology be at the end of TRL 5 or beyond before a project enters Phase B (see TRL definition chart provided in the Radiation Belt Storm Probes (RBSP) AO library

(<http://sso.larc.nasa.gov/rbsp/rbsplib.html>). Also, all technology must be at the end of TRL 6 or beyond to transition from Phase B to C (Formulation to Implementation). It is therefore imperative that detail development plans are provided to advance lower TRL technologies to the end of TRL 6 or beyond at the end of Phase B or provide evidence of maturity for technologies currently at $TRL \geq 6$. Investigations proposing new technology, i.e., technologies having a TRL less than 6, will be assessed a higher risk rating if adequate backup plans to ensure success of the investigation are not described. Heritage claims for technologies must be substantiated. If the instrument or components from which heritage is claimed, were developed and implemented by an institution and/or by a team other than the proposing institution and/or investigation team, explain how this heritage is applied and lessons learned incorporated. Instrument performance claims must be clearly substantiated.

3. Science Impacts on Mission Operations. This section should fully describe the science requirements that impact the operational phase of the mission. It should include information on science requirements that may affect the proposed launch date, and launch window constraints (if any). An observation plan to maximize science return (particularly for multiple instruments) must be presented.
4. Host Vehicle Accommodations. This section must describe in detail the accommodations required of the host vehicle and, as appropriate, the manufacturing facility to support the instrument(s). A “traceability matrix” showing how the proposed instrument accommodations comply with the stated objectives, requirements and constraints of the proposed investigation must be included. The instrument accommodations must include a discussion of all instrument(s) requirements that impact the various host vehicle subsystems, including attitude control (pointing, pointing stability, spin rate, etc.), mechanical (individual mass and mass margins, mounting constraints, co-alignment requirements between instruments of the instrument suite, optical fields of view, etc.), communications and data handling (peak and average data rates with margins, daily data volume, timing requirements within and between spacecraft, etc.), power and power margins (peak, average and survival & operational heater power, etc.), thermal (operational and survival, etc.), and propulsion (contamination sensitivity, etc.). Any requirements for host vehicle simulators should be stated.
5. Major Host Vehicle Trades. This section should discuss the major trades between the instruments and the host vehicle. The criteria for the final choices should also be presented. This section should include an overall proposed architecture for the instrument(s), including describing interdependencies of the instrument(s) hardware. If there are major departures from the original Step 1 proposal, they should be explained here. This section should also describe the future areas for trades between the instrument(s) and the host vehicle.
6. Fabrication and Test. Discuss the manufacturing strategy to produce, test, and verify the hardware/software necessary to accomplish the science goals of the instrument(s). Include a description of the main processes and procedures planned in the fabrication of

flight hardware, development of software, attainment of production personnel resources, incorporation of new technology/materials, and implementation of testing and verification programs. Provisions and facilities required to produce a set of one or more instruments, as appropriate, should be described. Discuss any past experience producing identical sets of instruments. If the fabrication and test procedures from which heritage is claimed were developed and implemented by an institution and/or team other than those proposing, explain how this heritage is applied and lessons learned incorporated. Describe plan to manufacture identical instruments and workforce plan to staff fabrication of identical sets of instruments. Discuss how the fabrication flow will support the project schedule. A description of the approach for transitioning from design to manufacturing should be included. The ability to assure reproducibility and adequacy of tooling availability should be addressed.

7. Integration and Test. The applicable environmental tests planned should be discussed in detail, and proposed test margins and durations for the environmental test program described. The approach, techniques, and facilities planned for integration, test and verification, and launch operations phases (including launch site testing and processing), consistent with the proposed schedule and cost, should be described. A preliminary schedule for manufacturing, integration, calibration and test activities should be included. A description of the planned end items, including engineering and qualification hardware, should be included.
8. Calibration and Inter-calibration. This section should describe the approach to calibrating, and inter-calibrating the instruments. Pre-launch and post-launch calibrations should be discussed. Any activities and constraints that will impact on the spacecraft level processing (e.g. removal of instruments after the spacecraft environmental test) should be discussed. Any activities that impact on mission operations (e.g. changing spacecraft orientation) after launch should be discussed.
9. Science Data Analysis. Data analysis methods and algorithms must be described. Their development should be discussed including resource allocation schedule and documentation.
10. Instrument Operations. This section should discuss any pre-planned campaigns, which include science requirements for observing modes, regions of interest, orientation, and maintenance. The planned approach for managing instrument operations and all flight operations support, including inputs to mission planning and scheduling, instrument command sequence generation, and data analysis should be discussed. A discussion of the system by which the instrument operations will be modified during the mission should be included. Describe all inter-facility communications, computer security, and near real-time ground support requirements, and indicate any special equipment or skills required of ground personnel. The Level 1 data products, software tools, and the timeframe they will be made available to the science community should also be discussed.

11. Facilities. Provide a description of any new, or modifications to existing, facilities, laboratory equipment, and ground support equipment (GSE) (including those of the investigation team's proposed contractors and those of NASA and other U.S. Government agencies) required to execute the investigation. The outline of new facilities and equipment must also indicate the lead-time involved and the planned schedule for construction, modification, and/or acquisition of the facilities.
12. Mission Assurance, Reliability and Safety. This section should describe the product quality assurance process to meet the NASA mission specifications, including identification of trade studies, the parts selection strategy, and the plans to incorporate new technology. Further information on the mission assurance requirements is detailed in the Geospace Mission Assurance Requirements (MAR) document, which is available from the Radiation Belt Storm Probes (RBSP) AO library (<http://sso.larc.nasa.gov/rbsp/rbsplib.html>). This section should also describe any waivers to the requirements that the investigation team plans to submit. Also include plans for problem/failure reporting, inspections, quality control, parts selection and control, reliability, safety assurance, and software validation.
13. Adherence to Accepted Management Processes and Practices. The CSR must encompass all technical aspects of the investigation from Phase B through delivery of the data and their analysis during Phase E. The document NPR 7120.5D, *NASA Space Flight Program and Project Management Processes and Requirements*, delineates activities, milestones, and products typically associated with Formulation and Implementation of space flight programs and projects and may be used as a reference in defining a team's mission approach. NPR 7120.5D may be found in the RBSP AO library (<http://sso.larc.nasa.gov/rbsp/rbsplib.html>). All missions must adhere to NPR 7120.5D in order to receive approval for implementation, that is, the initiation of Phase C through a NASA/SMD Confirmation process.

While investigation teams have the freedom to use their own processes, procedures, and methods to meet the requirements, they must plan to obtain Independent Verification and Validation (IV&V) from the NASA IV&V Facility in Fairmont, West Virginia, for all flight and ground software. IV&V must be accomplished in accordance with NPD 2820.1C, *NASA Software Policy* (found in the RBSP AO library, <http://sso.larc.nasa.gov/rbsp/rbsplib.html>). The NASA IV&V Facility provides an online self-assessment process, available at <http://ivvcriteria.ivv.nasa.gov/>, as a starting point for the investigation team to understand the risk and specific software development characteristics of their mission. Each investigation team must verify that they will obtain IV&V services from this NASA Facility. Note that this IV&V is not intended to substitute for good practices in software verification and validation performed by the investigation team. NASA covers the cost of these required IV&V activities.

G. MANAGEMENT PLAN

This section sets forth the investigator's approach for managing the work, the recognition of essential management functions, and the overall integration of these functions. This section must specifically discuss the decision-making process to be used by the investigation team, focusing particularly on the roles of the Principal Investigator (PI) and Project Manager (PM) in that process. The management plan gives insight into the organizations proposed for the work, including the internal operations and lines of authority with delegations, together with internal interfaces and relationships with NASA, major subcontractors, and associated investigators. It also identifies the institutional commitment of all team members, and the institutional roles and responsibilities. The use of innovative processes, techniques, and activities by investigation teams in accomplishing their objectives is encouraged; however, they must be employed only when cost, schedule, or technical improvements can be demonstrated and specific enabling assumptions are identified.

1. Investigation Team Member Responsibilities. This section must describe the roles, responsibilities, time commitment, and experience of all team member organizations and key personnel, with particular emphasis placed on the responsibilities assigned to the PI, the PM, and other key personnel. In addition, information must be provided which indicates what percentage of time key personnel will devote to the investigation, the duration of service, and how changes in personnel will be handled.
 - a. Organizational Structure. The management organizational structure of the investigation team must be described in the CSR. A Work Breakdown Structure (WBS) must be provided (see Appendix G of NPR 7120.5D). The CSR must describe the responsibilities of each team member organization and its contributions to the investigation. How each key position, including its roles and responsibilities, fits into the organization? Clear lines of authority must be presented and the basic qualifications required for each key position must be described. A discussion of the unique or proprietary capabilities that each member organization brings to the team, along with a description of the availability of personnel at each partner organization to meet staffing needs must be included. The contractual and financial relationships between team partners must be discussed.

Summarize the relevant institutional experience in this section, and refer to supporting detail included in Section K. 2., Relevant Experience and Past Performance, of this document. If experience for a partner is not equivalent to, or better than, the requirements for the proposed investigation, explain how confidence can be gained that the investigation can be accomplished within cost and schedule constraints.

- b. Experience and Commitment of Key Personnel. Provide a history of experience explaining the relationship of the previous experience to each key individual's role; include the complexity of the work and the results.
 - i. Principal Investigator. The role(s), responsibilities, and time commitment of the Principal Investigator must be discussed. Provide a reference point of contact, including address and phone number.

- ii. Project Manager. The role, responsibilities, time commitment, and experience of the Project Manager must be discussed. Provide a reference point of contact, including address and phone number.
 - iii. Other Key Personnel. The roles, responsibilities, time commitments, and experience of other key personnel in the investigation including Co-Investigators must be described. Those investigations that include Co-Is or other key personnel that are not identified as having key specific responsibilities will be penalized.
2. Management Processes and Plans. This section must describe the management processes and plans necessary for the logical and timely pursuit of the work, accompanied by a description of the work plan. This section must also describe the proposed methods of hardware and software acquisition. The proposed management processes, emphasizing the relationship between organizations and key personnel, must be discussed including the following as applicable: systems engineering and integration; requirements development; configuration management; schedule management; team member coordination and communication; progress reporting, both internal and to NASA; performance measurement; and resource management including financial. This discussion must address all phases of the mission and include preliminary analysis, technical definition, design and development, descopes, instrument operations phases, and expected products. The expected results from each phase should also be presented.

Unique tools, processes, or methods, which will be used by the investigation team, must be clearly identified and their benefits discussed. The philosophy to be used for spares should be defined and discussed. All project elements must be covered to assure a clear understanding of project-wide implementation.

3. Schedules. The schedule and workflow for the complete mission life-cycle must be clearly defined, and the method and tools to be used for internal review, control, and direction discussed. Schedules for all major activities, interdependencies between major items, deliveries of end items, critical paths, schedule reserves and margins, and long-lead procurement needs (defined as hardware procurements required before the start of Phase C/D) must be clearly identified and discussed.
4. Risk Management. This section must describe the approach to, and plans for, risk management to be taken by the investigation team, both in the overall investigation design and in the individual systems and subsystems. Plans for using standard risk management tools, especially fault tree analysis, probabilistic risk assessments, failure modes (emphasizing critical single point failures) and effects analyses, must be described. A preliminary risk assessment must be performed which identifies the major technical, programmatic and budget risks. The top 3 to 5 risks and their mitigation plans must be discussed. Particular emphasis must be placed on describing how the various elements of risk, including new technologies used, will be managed to ensure successful accomplishment of the investigation within cost and schedule constraints. Investigations proposing new technology, i.e., technologies having a TRL less than 6, will be assessed a

higher risk rating if adequate backup plans to ensure success of the investigation are not described.

In the interest of offsetting potential schedule risk, the investigation team shall identify all long lead procurements that must be ordered during Phase B to preserve the alignment of the development schedule with the master schedule.

Investigations, which have a significant no-cost foreign contribution shall define the specific coordination and control measures that will be employed to offset the programmatic risk inherent in the complexities of the teaming arrangement.

A summary of reserves in cost and schedule must be identified by Phase, project element and year and the rationale for them discussed. The specific means by which integrated costs, schedule, and technical performance will be tracked and managed must be defined. Specific reserves and the timing of their application must be described. Management of the reserves and margins, including who in the management organization manages the reserves and when and how the reserves are released, must be discussed. This must include the strategy for maintaining reserves as a function of cost-to-completion. All funded schedule margins must be identified. The relationship between the use of such reserves, margins, potential descope options, and their effect on cost, schedule, and performance must be fully discussed.

A clear descope plan shall identify pre-defined prioritized actions to preserve cost or schedule through a prudent reduction or deletion of requirements, science objectives, technical content or other efforts. The descope plans shall stipulate the specific descope actions, specify the schedule decision points for the effective execution, and shall estimate the projected cost and schedule savings associated with the actions. When considering potential descope options, consider the investigation as a total system including instrument(s), ground system, and operations.

5. Unique Property, Services and Facilities. The investigation team shall determine and identify all unique capital property, facilities or other exceptional services, which have to be constructed or procured for the execution of Phases B, C, D and E. The investigation team shall explain the need for such capabilities and shall provide associated cost and schedule estimates for future discussion with the GR-MOO Project Office. The investigation team shall not undertake undue obligations for these unique capabilities until the need has been reviewed and accepted by GR-MOO Project Office.
6. Government Furnished Property, Services, Facilities, etc. This section must clearly delineate the Government-furnished property, services, facilities, etc. required to accomplish all phases of the investigation.
7. Reviews. This section must list the major project reviews expected during the project's life cycle and the approximate time frame of each. The objective of each review must be indicated. The formal review program covering mandatory reviews is described in the

Geospace MAR available from the Radiation Belt Storm Probes (RBSP) AO library (<http://sso.larc.nasa.gov/rbsp/rbsplib.html>). Allowance must also be made for government-initiated independent assessment reviews, such as Confirmation Assessments, Independent Annual Reviews and Red Team Reviews. This section should also describe the peer review process to be implemented by the investigation team.

8. Reporting. This section must clearly describe the approach to reporting progress to the Government and indicate the progress reviews the Government is invited to attend to provide independent oversight. The process, including the individual or organization responsible for reporting integrated cost, schedule, and technical performance must be discussed. A description of the information to be presented must be included. Planned project status reporting to the GR-MOO Project office shall include: Monthly status reports, Quarterly presentations at the payload development site, and after the Project Critical Design Review (CDR), brief weekly progress summaries. Monthly status reporting products shall include cost, updated schedules, risks status and mitigation plans, and technical performance.

H. EDUCATION AND PUBLIC OUTREACH AND SMALL DISADVANTAGED BUSINESS PLAN

1. Education and Public Outreach. SMD is committed to fostering the broad involvement of the Space and Earth science research communities in Education and Public Outreach (E/PO) with the goal of enhancing the nation's formal education system and contributing to the broad public understanding of science, mathematics, and technology. Progress towards achieving this goal has become an important part of the broad justification for the public support of Earth and Space science. SMD sponsors a broad spectrum of educational activities ranging from kindergarten to postgraduate levels via several vehicles of solicitation.

Every CSR must contain an E/PO statement of commitment. However, E/PO will not be an evaluation factor in the selection process for the GR-MOO investigations. Proposers are welcome to provide a brief discussion of any unique characteristics of their investigation that might provide unusual opportunities for E/PO.

2. Small Disadvantaged Businesses (SDB) and Minority Institutions. A summary plan is required specifying the proposed investigation's commitment to meet NASA's SDB and other minority institution participation goals as described in Section XIII of Appendix A of the AO. In addition, as also specified in Appendix A of the AO, subcontracting plans will be required to execute the contract option for investigation implementation. Phase A funds can no longer be used to develop SDB subcontracting plans. Reimbursement for SDB subcontracting plans can only be as an indirect, so-called bid and proposal, cost.

I. TECHNICAL DEFINITION (PHASE B) PLAN

This section must describe the plans and products for the technical definition phase (Phase B) of the Project. The key investigation tradeoffs and options to be investigated during the Phase B must be identified. This section must identify those issues, technologies, and decision points critical to mission success. These plans must include a detailed schedule and define the products (including a Project Plan) and the schedule for their delivery.

J. COST PLAN

The cost plan must provide information on the incurred Phase A cost and anticipated costs of Phases B through E for a realistic launch date. A detailed cost proposal is required for Phase B/C/D. Cost estimates are required for Phase E, including a full description of the estimating techniques used to develop the cost estimates. A clear and detail discussion of the basis of estimate must be provided with an explanation of flight heritage and commonality with other projects. Quantify and explain any cost savings that result from heritage. *All costs, including all contributions made to the investigation, must be included.*

Proposers shall outline their reserves plan indicating the appropriate amounts of technical, schedule, and cost reserves based on design maturity and flight heritage. All investigations must include adequate reserves at every phase of the mission. In particular, investigations must plan to maintain a reserve through the end of Phase B of at least 25 percent of *all costs* to be expended through to the end of Phase D. A cost reserve for Phase E must also be included as appropriate. Proposers should not assume that the GR-MOO Project Office will maintain any reserves beyond those proposed. In general, schedule reserve must be approximately four weeks per year for Phases C and D.

Proposers must complete a summary of total mission cost by fiscal year as shown in **Figure 1**, Total Investigation Cost Funding Profile. The purpose of this summary is to present all costs for the project *on one page*, by project Phase (A through E), by participating organization, and by fiscal year. If obligation authority in excess of identified costs is required, the proposal must also indicate the authority needed by year. (Note: “fiscal year” shall be interpreted to be Government Fiscal Year throughout this document unless specified otherwise.)

In addition, for each phase of the investigation (B/C/D, and E) a Time Phased Cost Breakdown for each Work Breakdown Structure (WBS) element, as shown in **Figure 2**, must be completed. Use only the line items shown in Figure 2 that are relevant for each phase of the project. The purpose of this set of Figures is to provide detailed insight into how the project allocates funding during each phase of work.

The cost of the entire project must be summarized (on one page if possible), and presented in the format shown in **Figure 3**. The purpose of Figure 3 is to (1) provide detailed insight into project costs by cost element and (2) provide a basis for comparison of the project proposed cost with the evaluation team’s independent cost analysis. Identify each reserve amount to the lowest level consistent with the proposed reserve management strategy. For example, if each subsystem manager will have spending authority over a reserve for the subsystem, each

such amount must be identified separately. If more convenient, the reserve details may be shown in a separate table, with totals reported as shown in Figure 3. Show costs for all development elements by recurring and non-recurring components in the format of **Figure 4**. Show costs (NASA SMD and contributed) associated with each Co-Investigator in the format of **Figure 5**. All co-investigators must be included in Figure 5. Note that all contributions, including Co-I support, must be documented by Letter of Endorsements. Proposer must also provide a detailed cost breakout organized by their project-specific WBS as part of the cost plan.

Proposers must include all contributions provided by non-SMD and SMD programs at NASA Centers, including Civil Servant services, as well as the cost for the use of Government facilities and equipment on a full-cost accounting basis. All direct costs associated with the work performed at NASA Centers must be fully costed and accounted for in the proposal and summarized using the template provided in Figure 6. NASA Center Management and Operations (M&O previously known as Center G&A, IT, and facility service pools) and Independent Technical Authority (ITA) estimates need to be included, and separately identified using the center's out-year rate projection. The purpose of this data is twofold: 1) to determine those costs that are included in the NASA SMD cost but are not funded out of the LWS GR-MOO program, and 2) to determine civil service contributions that are not included in the NASA SMD cost. Investigation teams should work with their respective NASA Centers to develop estimates for these costs.

Note that the definitions for cost element terms shown in the cost figures are given in Appendix A of this document. This is not to be confused with the elements of cost listed in 1.e below.

The inflation index provided in Appendix B (Table B4) of the AO must be used to calculate all real-year dollar amounts, unless an industry forward pricing rate is used. If something other than the provided inflation index is used, the rates used must be documented.

1. Definition, Design, and Development (Phase B/C/D) Cost Proposal. This section provides a detailed cost proposal for performing Phase B/C/D. The cost proposal should clearly correlate with the plans set forth in the Science, Technical Approach, Schedule, and Management sections of the CSR.
 - a. Work Breakdown Structure (WBS). A WBS must be included for Phase B/C/D. The structure of the WBS should be consistent with the plans set forth in the Technical Approach and Management sections of the CSR and the Statement of Work provided as an Appendix to the CSR. The WBS shall be described to the major component level for more complicated instruments. All other elements of the WBS must be at least to the major task level (e.g., Project Management, Systems Engineering, Ground Support Equipment).

- b. Workforce Staffing Plan. Provide a workforce staffing plan that is consistent with the Work Breakdown Structure. This workforce staffing plan must include all team member organizations and must cover all management, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the Principal Investigator, Project Manager, Co-Investigators, and other key personnel must be clearly shown.
- c. Proposal Pricing Technique. Describe the process and techniques used to develop the Phase B/C/D cost proposal. For portions of the cost proposal developed using a grass-roots methodology, provide the basis from which the estimates were derived and details on how the estimates were extrapolated from the basis. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/etc. include sufficient information to understand the fidelity of the values. For portions of cost the proposal derived from analogies, describe the analogy's value and the methodology for extrapolation. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase B/C/D cost estimate. Discuss the heritage of the models and/or techniques applied to this estimate, including any known differences between instruments contained in the model's data base and key attributes of the proposed instrument. Include the assumptions used as the basis for the Phase B/C/D cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for producing multiple copies of identical instruments, business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- d. Phase B/C/D Time-Phased Cost Summary. Provide a summary of the total Phase B/C/D costs consistent with Figure 2. The Phase B/C/D cost summary should be developed consistent with the Work Breakdown Structure and must include all costs to NASA SMD along with all contributed costs. The Phase B/C/D time phased cost summary must be phased by fiscal year.
- e. Elements of Cost Breakdown. To effectively evaluate the Phase B/C/D cost proposals, NASA requires cost or pricing data as defined in FAR 15.401 and supporting evidence stating the basis for the estimated costs by the WBS levels used in Figure 2. This information is in addition to that provided in Figures 1 through 6. Provide Tables for each phase in the format in Figure 7. The proposal will include, but is not limited to the following elements of cost:
 - i. Direct Labor.
 - (1) Labor cost should be itemized by skills categories. Explain the basis of labor-hour estimates for each of the labor classifications.
 - (2) State the number of productive work-hours per month.
 - (3) Provide a schedule of the direct labor rates used in the proposal. Discuss the basis for developing the proposed direct labor rates for the team member

organizations involved; the forward-pricing method (including midpoint, escalation factors, anticipated impact of future union contracts, etc.); and elements included in the rates, such as overtime, shift differential, incentives, allowances, etc.

- (4) If available, submit evidence of Government approval of direct labor rates for proposal purposes, each labor classification, and the proposed performance period.
- ii. Direct Material. Submit a summary of material and parts costs for each element of the WBS. Provide supporting details for major vendors. Burden rates must be identified.
- iii. Subcontracts. Identify fully each effort (task, item, etc. by WBS element) to be subcontracted, and list the selected or potential subcontractors, locations, amount budgeted/proposed, and types of contracts. Explain any anticipated adjustments and indirect rates (or burdens) applied to the subcontractors' proposed amounts. Describe fully the cost analysis or price analysis and the negotiations conducted regarding the proposed subcontracts. Note that during the negotiation of any contract award, the Government reserves the right to obtain the same level of details as requested from the proposer. Phase A funds can no longer be used to develop subcontracting plans. Reimbursement for subcontracting plans can only be as an indirect, so-called bid and proposal, cost.
- iv. Other Direct Costs.
 - (1) Travel, Relocation, and Related Costs. Provide a summary of the travel and relocation costs including the number of trips, duration, and purpose.
 - (2) Computer. Provide a summary of all unique computer-related costs.
 - (3) Consultants. Indicate the specific task area or problem requiring consultant services. Identify the proposed consultants, and state the quoted daily rate, the estimated number of days, and any associated costs (such as travel). State whether the consultant has been compensated at the quoted rate for similar services performed in connection with Government contracts.
 - (4) Other. Explain and support any other direct costs included in the Phase B/C/D proposal in a manner similar to that described above.
- v. Indirect Costs.
 - (1) List all indirect expense rates for the team member organizations. Indirect expense rates include labor overhead, material overhead, general and administrative (G&A) expenses, and any other cost proposed as an allocation to the proposed direct costs.
 - (2) If the proposal includes support services for which off-site burden rates are used, provide a schedule of the off-site burden rates. Include a copy of the company policy regarding off-site vs. on-site effort.
 - (3) If available, submit evidence of Government approval of any/all projected indirect rates for the proposed period of performance. Indicate the status of rate negotiations with the cognizant Government agency, and provide a comparative listing of approved bidding rates and negotiated actual rates for the past five (5) fiscal years.

- (4) Discuss the fee arrangements for the major team partners.
- vi. Cost Of Money (COM). COM represents interest on borrowed funds invested in facilities. COM should be itemized by indirect pools and overhead centers. Rates should be documented.
- vii. Profit/Fee. Document the basis, rate, and amount of fee. Document the fee arrangements for the major team partners.
- viii. Escalation Factors. Document the escalation factors used to determine real year dollars.
2. Science Operations and Data Analysis (Phase E) Cost Estimate. This section provides a cost estimate for performing the Science Operations and Data Analysis Phase (Phase E) portion of the mission. The Phase E cost estimates should correlate with the plans set forth in the Science, Technical Approach, Schedule, and Management sections. In completing this section, the following guidelines will apply:
- a. Work Breakdown Structure (WBS). A WBS must be included for the Science Operations and Data Analysis Phase of the mission. The WBS should be consistent with the plans set forth in the Technical Approach and Management sections and the Statement of Work that is provided as an Appendix to the CSR.
- b. Cost Estimating Technique. Describe the process and techniques used to develop the Phase E cost estimate. For portions of the cost proposal developed using a grass-roots methodology, provide the basis from which the estimates were derived and details on how the estimates were extrapolated from the basis. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/etc. include sufficient information to understand the fidelity of the values. For portions of cost the proposal derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in your Phase E cost estimate. Discuss the heritage of the models applied to this estimate including any known differences between operations contained in the model's database and key attributes of the proposed operations. Include the assumptions used as the basis for the Phase E cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for operating multiple identical instruments, business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- c. Workforce Staffing Plan. Provide a workforce staffing plan (including civil service), which is consistent with the WBS. This workforce staffing plan must include all team member organizations and must cover all management, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal

- year. Time commitments for the Principal Investigator, Co-Investigators, Project Manager, and other key personnel must be clearly shown.
- d. Phase E Time-Phased Cost Summary. Provide a summary of the total Phase E costs consistent with Figure 2. The Phase E cost summary should be developed consistent with the WBS and must include all costs to NASA SMD, along with all contributed costs. The Phase E time phased cost summary *must be phased by fiscal year*.
 - e. Elements of Cost Break Down. Provide cost or pricing data as defined in FAR 15.401 and supporting evidence stating the basis for the estimated cost including but not limited to the elements of cost described under section K.1.e above.
3. Total Investigation Cost Estimate. This section must summarize the estimated costs to be incurred in Phases A through E including: Concept Study (Phase A), Technical Definition (Phase B); Design and Development Phase (Phase C/D); Science Operations and Data Analysis Phase (Phase E); and other ground system costs; and cost of activities associated with social or educational benefits (if not incorporated in any of Phases A through E). Figure 1 must be used to summarize these costs. The total investigation cost estimate should be developed consistent with the WBS. Detailed plans for any aspects of the mission not discussed elsewhere in the CSR must be discussed here. The funding profile must be optimized for the investigation. Contributions not included in the NASA SMD cost must be clearly identified as separate line items.

FIGURE 1. TOTAL INVESTIGATION COST FUNDING PROFILE TEMPLATE
(FY costs* in Real Year Dollars, Totals in Real Year and FY 2007 Dollars)

Item	FY06	FY07	FY08	FY09	FY10	...	FY15	Total (Real Yr.)	Total (FY 2007)
Phase A	\$	\$	\$	\$	\$	\$	\$	\$	\$
- Organization A									
- Organization B									
- etc.									
Phase B	\$	\$	\$	\$	\$	\$	\$	\$	\$
- Organization A									
Phase C/D	\$	\$	\$	\$	\$	\$	\$	\$	\$
- Organization A									
Phase E									
- Organization A									
Other (specify)	\$	\$	\$	\$	\$	\$	\$	\$	\$
NASA SMD Investigation Cost	\$	\$	\$	\$	\$	\$	\$	\$	\$
Contributions by Organization (Non-U.S. or U.S.) to:									
Phase A	\$	\$	\$	\$	\$	\$	\$	\$	\$
- Organization A									
Phase B	\$	\$	\$	\$	\$	\$	\$	\$	\$
- Organization A									
Phase C/D	\$	\$	\$	\$	\$	\$	\$	\$	\$
- Organization A									
Phase E									
- Organization A									
Other (specify)	\$	\$	\$	\$	\$	\$	\$	\$	\$
Contributed Costs (Total)	\$	\$	\$	\$	\$	\$	\$	\$	\$
Investigation Totals							\$	\$	

* Costs must include all costs including fee

FIGURE 2. Time Phased costs in Real Year Dollars, Totals in Real Year and FY2007 Dollars

TIME PHASED COST BREAKDOWN BY WBS AND MAJOR COST CATEGORY					
WBS/Cost Category Description	FY07	FY08	...	Total (RY\$)	Total (FY2007\$)
Total Direct Labor Cost	\$	\$	\$	\$	\$
WBS 1.0 Management					
WBS 2.0 Instrument 1					
Lower-level WBS elements for Instrument 1					
etc.					
Total Subcontract Costs	\$	\$	\$	\$	\$
WBS # and Description					
:					
etc.					
Total Materials & Equipment Cost	\$	\$	\$	\$	\$
WBS # and Description					
:					
etc.					
Total Reserves	\$	\$	\$	\$	\$
WBS # and Description					
:					
etc.					
Total Other Costs	\$	\$	\$	\$	\$
WBS # and Description					
:					
etc.					
Fee					
Other (Specify)					
Total Contract Cost	\$	\$	\$	\$	\$
Total Other Costs to NASA SMD	\$	\$	\$	\$	\$
Ground Segment					
Other (Specify)					
Total Contributions (Non-U.S. or U.S.)	\$	\$	\$	\$	\$
Organization A:					
WBS # and Description					
etc.					
Organization B:					
WBS # and Description					
etc.					
TOTAL COST FOR PHASE	\$	\$	\$	\$	\$

Figure 3. Fiscal Year Costs in Real Year Dollars (to nearest thousand)

(Totals in Real Year and Fiscal Year 2007 Dollars)

Cost Element	FY1	FY2	FY3	...	FYn	Total (RYS)	Total (FY2007\$)
Phase A							
Reserves							
Total Phase A							
Phase B							
Reserves							
Total Phase B							
Phases C and D							
Instrument A							
Instrument B							
Instrument Integration, Assembly & Test							
<i>Subtotal - Instruments</i>							
Proj Mgmt/Miss Analysis/Sys Eng/Miss Assurance							
Science Team Support							
Prelaunch GDS/MOS Development							
Other*							
<i>Subtotal before Reserves</i>							
Instrument Reserves							
Other Reserves							
Total Phases C and D							
Phase E							
MO&DA							
Other*							
<i>Subtotal Phase E before Reserves</i>							
Reserves							
Total Phase E							
Total NASA SMD Cost	\$	\$	\$	\$	\$	\$	\$
Contributions*							
Total Contributions	\$	\$	\$	\$	\$	\$	\$
						Total Investigation Cost	\$

*Specify each item on a separate line; e.g., facilities, etc.

Figure 4. Phase B/C/D Development Costs in Real Year Dollars (nearest thousand)

Cost Element	Non-Recurring	Recurring	Total (RYS)	Total (FY2007\$)
Instrument A *				
Instrument B*				
Instrument n *				
<i>Subtotal - Instruments</i>				
Any other elements (specify)				
<i>Subtotal - Other elements</i>				
Total NASA SMD Development Cost				

*Specify each instrument by subsystem/components where possible

FIGURE 5. Co-Investigator Commitment and Cost Funding Profile Template

(Phase costs in Real Year Dollars, Totals in Real Year and FY2007 Dollars)

	Phase B	Phase C/D	Phase E	Total (Real Year)	Total (FY 2007)
<i>NASA SMD Cost</i>					
Co-I # 1 Name/Organization					
Percent Time					
Cost					
Co-I #2 Name/Organization					
Percent Time					
Cost					
Co-I #n Name/Organization					
Percent Time					
Cost					
Total NASA SMD Co-I Cost					
<i>Contributions</i>					
Co-I # 1 Name/Organization					
Percent Time					
Cost					
Co-I #2 Name/Organization					
Percent Time					
Cost					
Co-I #n Name/Organization					
Percent Time					
Cost					
Total Contributed Co-I Cost					

FIGURE 6. NASA Civil Service Cost Funding Profile Template

(FY costs in Real Year Dollars, Totals in Real Year and FY2007 Dollars)

Item	FY07	FY08	FY09	FY10	FY11	...	FY13	Total (Real Yr.)	Total (FY 2007)
Workforce	\$	\$	\$	\$	\$	\$	\$	\$	\$
- NASA Center A									
- NASA Center B									
- etc.									
Facilities	\$	\$	\$	\$	\$	\$	\$	\$	\$
- NASA Center A									
Other*	\$	\$	\$	\$	\$	\$	\$	\$	\$
- NASA Center A									
M&O and ITA									
- NASA Center A									
- NASA Center B									
NASA Civil Service Costs included in NASA SMD Cost	\$	\$	\$	\$	\$	\$	\$	\$	\$
Contributions by NASA Centers									
Workforce	\$	\$	\$	\$	\$	\$	\$	\$	\$
- NASA Center A									
- NASA Center B	\$	\$	\$	\$	\$	\$	\$	\$	\$
- etc.	\$	\$	\$	\$	\$	\$	\$	\$	\$
Facilities									
- NASA Center A									
Other*									
- NASA Center A									
M&O and ITA									
- NASA Center A									
- NASA Center B									
Contributed NASA Civil Service costs	\$	\$	\$	\$	\$	\$	\$	\$	\$
							Investigation Totals		\$

*Specify each item on a separate line.

Figure 7 Summary Of Elements Of Costs (\$K)

Real Year Dollars

WBS #/Title: _____

Check One: _____ PHASE B _____ PHASE C/D _____ PHASE E

	FY07	FY08	FY09	FY10	FYn	Total
Direct Labor Hrs: (By skill categories)						
Direct Labor Cost: (by skill categories)						
Total Direct Labor Costs						
Overhead (by cost Centers)						
Other Direct Costs						
Subcontracts						
Materials						
Material Burdens						
Travel						
Other Direct Costs						
Subtotal						
G&A Expense (by cost pools)						
Subtotal						
Cost of Money (by direct pools & overhead centers)						
Profit/Fee						
Total Cost Plus Fee						

Figure 8

MASTER EQUIPMENT LIST Template - Items shown are for example purposes only

		Unit Mass, Current Best Estimate (CBE)	# of Units				Flight Hardware Summary			Other Component Information	
Subsystem	Component		Flight Units	Flight Spares	Engrng Models	Proto- types	Total Mass, CBE	Contingency %	Total Mass w/ Contingency	Description (Vendor, Part #, Heritage Basis)	Other characteristics/issues (volume, power, other component specific items)
Instruments/Payload											
Instrument 1 (separate breakout for each instrument)	Structures										
	Mechanisms										
	MLI										
	Radiators										
	Cryocoolers										
	Heat pipes										
	Optics										
	Focal Plane - Detectors										
	Focal Plane - R/O Electr										
	Cmd & Cntrl Electr										
	Others										

K. APPENDICES

The following additional information is required to be supplied with the CSR. This information can be included as Appendices to the CSR, and, as such, will not be counted within the specified page limit.

1. Letters of Endorsement. Letters of endorsement must be provided from *all* participating organizations and other organizations critical to the investigation. This requirement also applies to all organizations making contributions. Letters of endorsement must be signed by both the lead representative from each organization represented on the investigation team, and by institutional and Government officials authorized to commit their organizations to participation in the proposed investigation. If government funding is required to support a contribution, a letter of support or commitment is required from the government funding agency, signed by an official authorized to commit the agency. Institutional letters of endorsement for *all* Co-Investigators are required.
2. Relevant Experience and Past Performance. Proposals must include a discussion of *relevant* experience and past performance by the major team partners in meeting the requirements of projects *similar* to the subject of this CSR. This can include airborne or space-based instrument development and investigations. For this part of the CSR, we are seeking information *about the partner organizations* rather than individuals. Projects that ended more than 5 years ago need not be included in the discussion. The discussion of relevant experience and past performance must include a description of each project; its relevance to the subject of the CSR; the proposed performance and the actual performance; the proposed cost and actual cost; the proposed schedule and actual schedule; an explanation of any differences between proposed performance, cost and schedule and what was actually achieved; and points of contact for the past project's customer. If the customer for the past project was the United States government, then the contract number must be included along with current technical point(s) of contact and phone number(s). For projects that are not yet complete, the current projected performance, cost, and schedule must be used in place of actual values.

In evaluating the CSR, NASA will consider the past performance of the major partner organizations. The evaluation of past performance will not be arithmetic; instead, the information deemed to be most relevant and significant will receive the greatest consideration. Relevant experience will be viewed as the demonstrated accomplishment of work, which is comparable or related to the objectives of the CSR. This includes airborne or space-based instrument development and investigations and associated development processes including engineering processes, management processes, operations, data analysis and archiving. NASA will review the past performance information provided by the proposer. In addition, NASA may review the major team partners past performance on other NASA and/or non-NASA projects or contracts that provide insight into those institutions past performance on airborne or space-based instrument development and investigations and associated development processes including engineering processes, management processes, operations, data analysis and

archiving. In conducting the evaluation, NASA reserves the right to use *all* information available.

The investigation team is cautioned that omissions or an inaccurate or inadequate response to this evaluation item will have a negative effect on the overall evaluation, and while NASA may consider data from other sources, the burden of providing relevant references that NASA can readily contact rests with the investigation team.

3. Resumes. Provide resumes for *all* key personnel identified in the Management section. Include resume data on experience that relates to the job these personnel will be doing for the proposed investigation.
4. Statements of Work for each Contract Option. Provide draft Statement(s) of Work for *all* potential contracts with NASA. These Statement(s) of Work must (as a minimum) be for each contract option (i.e., Phase B/C/D, and Phase E) and clearly define all proposed deliverables (including science data) for each option, potential requirements for Government facilities and/or Government services, and a proposed schedule for the entire mission.
5. Data Management Plan. A draft Data Management Plan is required.
6. Incentive Plan(s). Draft Incentive Plans (if applicable) must be included. Incentive Plans must outline contractual incentive features for *all* major team members. Incentive Plans must include both performance and cost incentives, as appropriate.
7. NASA PI Proposing Investigation Teams. The same guidelines as in AO Appendix B section H. 7 apply.
8. Technical Content of any International Agreement(s). Draft language for the technical content of any International Agreement(s) are required for all non-U.S. partners in the investigation. A sample Letter of Agreement (LOA) is available in the RBSP AO library (<http://sso.larc.nasa.gov/rbsp/rbsplib.html>). The draft language must include (i) a brief summary of the mission and the foreign partner's role, (ii) a list of NASA's responsibilities within the partnership, and (iii) a list of the non-U.S. partner's responsibilities in within the partnership. Note that NASA prefers to establish agreements with government funding agencies, not with the institution that will be funded to perform the work.
9. Discussion on Compliance with U.S. Export Laws and Regulations. Provide an update to the discussion in the original Step 1 proposal. Investigations that include international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities must include a section discussing compliance with U.S. export laws and regulations; e.g., 22 CFR 120-130, *et seq.* and 15 CFR 730-774, *et seq.*, as applicable to the scenario surrounding the particular international participation. The discussion must describe in detail the proposed international participation and is to include, but not be

limited to, whether or not the international participation may require the proposer to obtain the prior approval of the Department of State or the Department of Commerce via a technical assistance agreement or an export license, or whether a license exemption/exception may apply. If prior approvals via licenses are necessary, discuss whether the license has been applied for or if not, the projected timing of the application and any implications for the schedule. Information regarding U.S. export regulations is available at the RBSP AO Library (under NASA Export Control Program) and through Internet URL <http://www.pmdtc.org>. Proposers are advised that under U.S. law and regulation, spacecraft and their specifically designed, modified or configured systems, components, parts, etc., such as the instrumentation being sought under this program, are generally considered “Defense Articles” on the United States Munitions List and are therefore subject to the provisions of the International Traffic in Arms Regulations, 22 CFR 120-130, *et seq.*

10. Draft Program Level Requirements. A draft of the Program Level Requirements, which includes instrument requirements and specifications development, must be provided. An example of a Program Level Requirements document for Aeronomy of Ice in the Mesosphere (AIM) is found in the RBSP AO library (<http://sso.larc.nasa.gov/rbsp/rbsplib.html>). The Program Level Requirements must be explicitly described and must be linked to the scientific objectives of the mission. The requirements that these objectives and observations impose on the mission design elements must be discussed. The investigation team must provide the science requirements to meet the full mission success criteria and the minimum mission success criteria.
11. Acronyms List.
12. References List (Optional). Concept studies may provide, as an appendix, a list of reference documents and materials used in the concept study. The documents and materials themselves cannot be submitted, except as a part of the CSR.

APPENDIX A

PROGRAM COST ELEMENT DEFINITIONS

Introduction

This is a short dictionary of definitions for the cost elements shown in the figures and tables and discussed in the body of this *Guidelines and Criteria for the Geospace-Related Missions of Opportunity Phase A Concept Study* document.

Project Management/Systems Engineering

Project management costs include all efforts associated with project level planning and directing of prime and subcontractor efforts and interactions, as well as project-level functions such as quality control and product assurance. Systems engineering is the engineering required to ensure that all instrument subsystems function properly to achieve mission goals and requirements. This cost element also includes the data/report generation activities required to produce internal and deliverable documentation.

Instruments

Instrument costs include costs incurred to design, develop and fabricate the individual scientific instruments or instrument systems through delivery of the instruments to the spacecraft for integration. Costs for instrument integration, assembly, test, and ground support equipment are to be shown separately from instrument development. Costs incurred for integration of the instruments to the spacecraft are included in the Spacecraft Integration, Assembly & Test cost element (see below).

Spacecraft Integration, Assembly & Test (IA&T)

Spacecraft integration, assembly and test is the process of integrating all spacecraft subsystems and payloads into a fully tested, operational satellite system. The total cost of IA&T for a satellite includes research/requirements specification, design and scheduling analysis of IA&T procedures, ground support equipment, systems test and evaluation, and test data analyses. Typical satellite system tests include thermal vacuum, thermal cycle, electrical and mechanical functional, acoustic, vibration, electromagnetic compatibility/interference, and pyroshock. This element encompasses only the support required from the instrument to support spacecraft IA&T. The spacecraft vendor will provide facilities and support personnel for the spacecraft element of the IA&T.

Launch Checkout & Orbital Operations

Launch checkout and orbital operations support costs are those involving pre-launch planning, launch site support, and the first 90 days of flight operations.

Pre-Launch Science Team Support

Includes all Phase B/C/D (pre-launch) support costs for the science team. See below for post-launch component.

Pre-Launch Ground Data System (GDS)/Mission Operations Services (MOS) Development

Includes costs associated with development and acquisition of the ground infrastructure used to process science data. Includes development of science data processing and analysis capability. Also includes pre-launch training of the science team, support for the development and execution of operations simulations, sequence development, and flight control software. It may be assumed that data and commanding will be provided via links between the instrument operations control center and the mission operations center.

Instrument Operations

Instrument operations comprise all activities required to plan and execute the science objectives, including instrument control, health monitoring, and calibration. Costs include all post-launch costs for people, procedures, services, hardware and software to carry out these activities.

Data Analysis (DA)

This cost element refers to Phase E (launch plus 30 days). Data analysis activities include collecting, processing, distributing and archiving the scientific data in the appropriate data archive. Costs include all post-launch budgets for people, procedures, services, hardware and software needed for DA. Includes science team support budgets post-launch.

Project-Unique Facilities

If the proposed project requires construction or lease of any ground facilities, include here only the portion of costs to be borne by the proposed project, with description of the nature and extent of any cost-sharing arrangements assumed.

Reserves

The proposer must include sufficient budget reserve such that all instrument issues can be accommodated and resolved within the total budget proposed. The GR-MOO Project Office will not hold any reserves to handle any instrument development and integration issues. The project will only hold reserves to accommodate impacts caused by changes outside control of the investigation team such as an unforeseen change in launch vehicle.

Reserves must be adequate to mitigate contingencies or underestimation of resources. Reserves must be reported according to the proposed reserve management strategy.

NASA Center Costs (all categories)

Additional costs borne by the project for NASA Center participation. For example, there may be additional project management/systems engineering costs, above those incurred by the instrument prime contractor, due to NASA employee participation. These costs must be reported on a full-cost accounting basis.

APPENDIX B

GUIDANCE FOR BALLOON MISSIONS: EVALUATION CRITERIA FOR THE SAFETY, RELIABILITY & QUALITY ASSURANCE REQUIREMENTS

1.0 GENERAL INFORMATION

This appendix is a supplement to the Guidelines and Criteria for the Geospace-Related Missions of Opportunity Phase A Concept Study with regard to tailoring the *evaluation criteria* for Safety, Reliability, and Quality Assurance for Mission of Opportunity Balloon Missions. Henceforth, for sake of distinction, the “Safety, Reliability, and Quality Assurance Requirements” will simply be referred to as the SR&QA. These criteria will be referred to as the Balloon SR&QA.

It is expected that a Balloon mission of opportunity Principal Investigator (PI) will conform to the Guidelines and Criteria for the Geospace-Related Missions of Opportunity Phase A Concept Study and, to the extent referenced within those guidelines, to the Geospace Mission Assurance Requirements (MAR) (found under Relevant Documentation at the Geospace-Related Mission of Opportunity (GR-MOO) Downselect Information website, <http://sso.larc.nasa.gov/rbsp/GRMOO.html>) when addressing mission assurance, reliability and safety using the specific alternatives addressed in this appendix. The Living with a Star Program office also anticipates that some amount of mission unique tailoring will be implemented when the final NASA mission assurance, reliability and safety requirements are applied to a balloon mission. It is not the purpose of this appendix to levy additional requirements on balloon missions but rather, to ensure those proposals for all types of missions have an equal opportunity to be selected. This is similar to the criteria enacted within the Explorer Program for competitive phase A studies.

It is understood that balloon missions differ significantly from space flight missions based on the environment and duration of a single flight and also the possibility of reflight. It is further recognized that significant differences will exist in needed environmental verification and qualification testing, as compared to longer duration orbital missions. It is the intent of the Living with a Star Program Office that Geospace-related mission of opportunity balloon missions will meet an adequate set of documented SR&QA requirements to augment science derived engineering requirements, therefore increasing the likelihood of success. This will later be used as the baseline for measuring adequacy of the selected investigation's Phase-A effort with respect to mission assurance.

2.0 QUALITY ASSURANCE

Quality System

During Phase B, the PI must implement a quality system. It is desired, but not required, that this be based on ISO-9001. The system is to be documented in a quality manual and/or implementation plan. This quality system should be based on the flight duration, the flight environment and number of required re-flights. Elements of the Quality Manual should incorporate those found within the Geospace MAR for Non-Compliance Report (NCR) reporting and corrective actions, material review, reporting of failures, control of monitoring and measuring devices, configuration management, ground support equipment, and requirements flow-down and documentation.

3.0 SAFETY

The PI is required to plan and implement a system safety program that identifies and controls hazards to personnel, facilities, support equipment, and flight system during all phases of mission development, launch, and operations. The program is to address hazards in the flight hardware, associated software, ground support equipment, and support facilities. PI conducted missions must also address safety for the launch operations, flight operations, and recovery operations.

The balloon mission of opportunity safety program must meet the system safety requirements stated in Columbia Scientific Balloon Facility (CSBF) documents “CSBF Ground Safety Plan” (CSBF document number OF-610-00-P Rev B) and “CSBF Payload Safety Plan” (CSBF document number OF-605-00-P Rev A). CSBF user documents can be obtained from: <http://www.csbf.nasa.gov/docs.html>. NASA supported Balloon Flight Operations & Mission Safety is managed by the NASA Balloon Program Office (BPO), who will insure compliance in accordance with science mission objectives. PI conducted missions will be reviewed for similar payload and ground safety planning and compliance by the Geospace Program Office and BPO.

Pyrotechnics – Pyrotechnics are often used for balloon flight termination systems. When incorporated, users must comply with NASA “Safety Standard for Explosives, Propellants, and Pyrotechnics which can be found at: http://www.hq.nasa.gov/office/codeq/doctree/1740_12.pdf.

Radiological Materials (flight) – Radiological flight materials must have Nuclear Launch Safety Approval (NSLA) prior to flight. PI’s are responsible to provide the Geospace Program SR&QA Manager with information as to isotope name, packaging, and levels for approval prior to PDR. Most requests take approximately 1 month to get approval.

Flight Safety – For PI conducted missions, a full description of the flight systems and operational concept must be provided to NASA BPO for purpose of performing a flight risk analysis. A Risk Analysis Report (RAR) will be completed by the NASA WFF Flight Safety

Group. The PI is responsible for using the RAR to generate Flight Rules that must be observed for each mission. BPO or PI conducted missions will be reviewed for the RAR during Critical Design Review (CDR) and for the flight rules prior to the Mission Readiness Review (MRR). Flight rules are a controlled document that must be submitted for LWS Geospace Program Office review and approval. Balloon missions of opportunity must comply with FAA Regulations Part 101, Subpart D that can be found under Relevant Documentation at the Geospace-Related Mission of Opportunity (GR-MOO) Downselect Information website (<http://sso.larc.nasa.gov/rbsp/GRMOO.html>).

Local & International Air Traffic Coordination – All balloon missions of opportunity will be conducted in accordance with local and international requirements. For PI conducted missions, it is the PI's responsibility to insure all local and international coordination, agreements, and requirements are met as required to conduct the mission to include overflight clearances, frequency clearances, NOTAMS and Air Traffic Control (ATC) coordination. Local range safety requirements will be annotated within the project safety and operations plans.

4.0 Reliability

Balloon mission of opportunity projects should conduct reliability analyses consistent with sections 4.1 through 4.2.1.2 of the Geospace MAR, to include referenced Contract Deliverable Requirement Lists (CDRLs) in order to identify and track critical hardware development and mission risks. For PI conducted missions, these analyses should account for hardware as well as all mission support elements. Based on shorter duration missions and multiple/redundant systems which are designed to mitigate risks while maintaining lower cost, parts stress analyses is not a requirement given that the verification requirements are met, as described in Section 7, below.

5.0 Software Assurance

Balloon missions of opportunity software assurance will be in accordance with the Geospace MAR.

6.0 Reviews

Same as noted in the Guidelines and Criteria for the Geospace-Related Missions of Opportunity Phase A Concept Study and Geospace MAR with the following revision. A test plan is required in the CDR. Balloon missions could have elaborate re-flight or multiple flight plans. These must be reflected in the test plan.

For missions requiring NASA Balloon Program support, program management is performed by NASA's BPO (Code 820) located at the Wallops Flight Facility. Together with the CSBF, who supports balloon launch and flight operations for NASA, the BPO oversees certain audit and reporting functions which include but are not limited to:

- Completion of the CSBF Balloon Flight Application.
- Establishing concise and achievable flight success criteria.
- Insuring gondola structural certification.
- Insuring thermal compatibility with CSBF flight systems.
- Insuring integration with applicable NASA CSBF flight support systems.
- Insuring mission planning that is consistent with established operational and safety guidelines.
- Review of responses to actions assigned from reviews, as described in the following section.

For PI conducted missions, similar reviews will be conducted by the Geospace Program Office throughout the project life-cycle, but will be tailored using the same standards as are applied for CSBF conducted missions. For example, CSBF performs mechanical flight systems structural certifications to insure compliance with parachute opening shock loading. Similarly, PI led balloon missions of opportunity will be reviewed to insure independent mechanical certification on PI provided flight systems has been performed.

In addition, the Geospace Program Office and BPO will conduct the following independent reviews. These reviews will be coordinated with the PI so that they can coincide with other reviews.

- Mission Initiation Conference – This review will be conducted at the beginning of Phase B. It will include the PI's team and representatives from the Living with a Star Program Office and BPO. Although the feasibility of each candidate mission's requirements will be reviewed prior to Phase-A, this Mission Initiation Conference will focus upon specific flight support requirements for the purpose of insuring assignments and tasks are properly assigned and being worked toward the program schedule requirements.
- Mission Readiness Review/Pre-Ship Review – This review is conducted immediately after completion of integration and testing of the PI's gondola and instrumentation with the flight support systems. This is a balloon program review required by NASA Headquarters prior to shipment to the remote launch site. The purpose of this review is to assess the readiness of the integrated payload. As a minimum, this review will focus upon the readiness and completeness of the science instrument, flight support systems, ground support systems, verification testing, Mission & Operations plans, Flight Rules, international agreements/coordination, etc. The objective at the time of this review is that all systems be integrated, tested, and definitions / configurations / certifications are complete.
- Flight Readiness Review (FRR) – This review is conducted at the launch site once the instrument and flight support systems have completed final integration and testing and are believed to be flight ready. This review covers not only the individual flight systems and related ground systems, but also includes a review of all the launch and mission elements. The purpose of this review is to establish that all pre-flight readiness preparations are

complete and to insure that both science and launch support personnel clearly understand the script for the launch, flight, and recovery operations. This review takes the place of the launch readiness review as described in the Geospace MAR section 6.3. Flight Readiness Reviews are valid for no more than 72 hours prior to actual launch. In the event that weather delays preclude launch after any given FRR, another FRR will be conducted as an update if more than 72 hours will have passed prior to launch.

- **Post Flight Review** – This review is conducted by the BPO to review all phases of pre-flight support, launch, flight and recovery operations. Solicitation of PI comments and recommendations as well as overall assessment of achieving the science mission requirements is the main focus of this review. The focus of this review is that of gathering quick-look feedback and lessons learned in preparation for incorporating enhancements/corrections for subsequent missions.

For PI conducted missions, the above reviews will be conducted by the Geospace Program Office and BPO with the project team. It is the PI responsibility to take into account mission planning to include the capability for conducting such reviews via teleconference for occasions where principle participants may be geographically dispersed.

7.0 Design Verification Requirements

The PI is required to conduct a verification program to ensure that the gondola and instrument(s) meet the specific mission requirements. The PI is required to prepare and submit adequate verification documentation including a verification matrix, environmental test matrix and verification procedures to the Living with a Star Program Office for review.

Mechanical

Mechanical analyses and independent certification suffice for strength/pull testing. In flight, balloon payloads will not experience the vibration levels encountered on Expendable Launch Vehicle (ELV) payloads. However, Pis must provide documentation of test methods and results and/or inspections, practices and records, which clearly demonstrate the mechanical integrity of wiring, circuit boards, and mechanical assemblies. This serves as a “proof of workmanship” verification. Low-level three-axis random vibration testing at sub-system levels may be considered as an acceptable means for verification. However, the BPO imposes no standards for vibration testing.

Typically, prior to flight, the most severe mechanical shock loads experienced by balloon payloads are those encountered during shipment, particularly over-the-road. Along with overall payload design considerations, the PI must plan for proper shipping containers that will be accommodated by commercial carriers. Shipping includes over-the-road, sea, and turbo-prop air transport. Handling at the launch site is normally a smooth transition from the payload preparation facility to the launch site.

At the end of the flight, shock loads associated with parachute opening and payload impact on the ground are the most severe mechanical loads associated with any balloon flight. NASA balloons flight systems are expected to meet mechanical certification criteria as described in document “Structural Requirements for Gondolas” that is available at: <http://www.csbf.nasa.gov/docs.html>. Albeit these requirements are established for gondola structures to insure integrity during end-of-flight parachute shock loading, if planning for the contingency of a quick turnaround of the payload for possible reflight, designers are advised not to reduce these load requirements when applying how they translate back into their design accounting for internal component shock load integrity for such items as circuit boards, gimbal mountings, cable harnesses, connectors, etc.

Electronic and Electro-Mechanical

The following test guidelines are generally considered adequate to verify balloon flight systems operability in preparation for flight:

- Full environmental screening (1 cycle) at worst case predicted hot/cold limits for hot/cold dwell times consistent with flight predictions, for all flight instrument and electro-mechanical systems. In addition, a 3 cycle hot-cold test be performed for all flight instrument and electro-mechanical systems with worst case predicted hot/cold limit dwells times sufficient as to achieve stabilized temperature saturation. These tests may be done with either the fully integrated payload or with separate subsystems. In the case of separate subsystems, it must be demonstrated that finished interface cable assemblies, etc, have also passed environmental screening. All systems must be demonstrated to work properly throughout the entire range of the test environment or shown to recover and work properly when transitioning back to nominal conditions, where it can be shown that mission requirements can still be met.
- Vacuum testing of all flight instrument and electro-mechanical systems over the entire predicted in-flight range to demonstrate that all systems work.
- Independent mechanical certification of all flight hardware is performed.
- Successful completion of hands-off, failure free operation of the final integrated instrument/flight support systems payload package and ground support systems, to be conducted for a duration no less than the minimum stated flight duration requirement, for at least one of the flight systems. In the case where multiple flight systems incorporate differences in design or type of components, then hands-off testing should be performed for each unique design/part type. (Multiple payloads having the exact design and component types need not undergo this hands-off test as long as at least one completed article of the same design and having the same component types has successfully undergone such a test.) Demonstration of failure-free operation tests must include their respective ground support systems (including networks/data/command routing elements.) The above requirement replaces the Geospace MAR requirement for 500 hours consecutive and 250 hours failure

free hands-off operation in orbital environments that is not required for balloon missions of opportunity.

Because of their lower cost, balloons can also provide for a relatively inexpensive means by which to test final systems designs and instrument operation. PIs are encouraged to fly new balloon borne instruments on a short duration test flight for the purpose of verifying proper operation of all flight, ground, and mission support elements. However, a short duration test flight is not a suitable substitute for thermal-vacuum qualification tests. Short test flights cannot be guaranteed to subject the payload to the environmental extremes that are likely to be encountered on a balloon mission.

8.0 Workmanship Standards and Processes

NASA balloon missions of opportunity must be designed in such a manner as to not compromise on safety. It is important to note that the NASA workmanship standards are written to be tailored based on their applicability guided by sound engineering principles and levels of acceptable risk. For example, NASA-STD-8739.1, “Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies” is not a requirement in its entirety for NASA balloon applications. Normally, conformal coating of Printed Wiring Boards (PWBs) for small quantity balloon applications is not considered practical from a cost and risk perspective. Care with handling, limiting exposure to contaminants, exercising care by maintaining PWBs in protective packaging, and planning for adequate spares along with the ability to quickly inspect and replace components immediately prior to launch have traditionally served as adequate mitigation toward benefits that would otherwise be realized by mandated conformal coating. However, conformal coating, when used, should be considered in accordance with NASA-STD-8739.1 in order to best insure quality of workmanship.

The same standard (NASA-STD-8739.1) addresses staking of wires and certain components. Although balloon missions do not experience vibration or shock during flight, at least until the very end, the PI should consider such risks that are likely to occur during pre-mission handling and shipment. Staking of wire assemblies and critical components to mitigate such risks should be addressed where applicable in the design.

Similarly, the PI should comply with the Applicable Documents referenced in the Geospace MAR, that are relevant to the design and proposed balloon mission scenario. Explanation should be given as to the cost, risk, and alternative mitigation trades that are being proposed in order to meet the objectives of safe, low-cost missions.

Standards specific to Space and Military requirements are not applicable to NASA balloon missions. However, NASA standards for workmanship and design (i.e. soldering, crimping and harnessing, grounding, ElectroStatic Discharge (ESD) Control, etc.), which are beneficial to all applications, should be reviewed carefully to insure applicable elements are being addressed.

9.0 Parts Requirements

The Principal Investigator is required to implement an appropriate Electrical, Electromechanical, and Electronic (EEE) parts program consistent with the proposed balloon mission concept for a Geospace-related mission of opportunity. A balloon mission will be of limited duration; however, the payload could be retrieved, refitted, and re-flown several times or multiple low-cost redundant payloads could be planned in order to achieve lower cost and risk. Thus, high quality commercial / industrial grade parts could be used on a balloon flight provided they are tested, inspected, properly stored and properly handled.

Balloon mission of opportunity projects should include a Parts Control Board (PCB) for electronic parts and materials planned or considered for incorporation in flight systems. PCB requirements are per the Geospace MAR.

Special Considerations

Balloons and Corona Discharging – Balloons transit and often operate in pressure regimes that are vulnerable to corona discharging. High voltage components must be operated through the entire pressure range, ground to float, to insure arcing does not cause latent damage or permanent failures. All parts should be life tested based on mission duration and pressure, and thermally tested through the entire balloon environment range, ground to float. Balloon systems can potentially impose high static electricity buildup on the balloon and parachute. Balloon electronic support and instrumentation systems must incorporate proper grounding and shielding to mitigate risks associated with potential static discharges.

Balloons Unique Thermal Environment – Balloons are typically subject to longer diurnal cold and hot case dwell times. As a minimum, life cycle thermal testing should verify that all systems will continue to operate for the entire flight duration as bounded by nominal thermal hot and cold cases and thermal cycling. And demonstrate that all systems will recover and operate successfully after undergoing predicted thermal extreme hot and cold cases. Any operational mode that is tailored to accommodate any thermal operational limitation of the scientific instrument(s) must be indicated in the test plans and operations plans.

The PI is required to provide a plan for implementing environmental testing that is appropriate to the mission. Thermal-vacuum testing must be conducted in such a manner as to demonstrate not only the thermal model, but also to provide system qualification. Thermal qualification testing for balloon missions can be more extreme than that required for space-based systems because of the dwell times, albedo, etc. Balloons can be subject to several hours of daylight receiving direct solar and reflected (albedo) radiation. The night time environment can last several hours which includes not only cold sky, but also contribution from cold cloud tops, albedo, etc.

As part of Phase B, the PI must provide a detailed thermal analysis. In turn, the CSBF's thermal analyst will use this information to insure close-coupled flight support systems are operating

within proper limits (for BPO/CSBF supported missions) and to insure the PI's instrument is not adversely affected by support systems. PIs are advised to schedule the services of a thermal analyst from the beginning through the final design configuration phase in order to be responsive to addressing configuration changes that might arise during the development, fabrication, and integration phases.

Thermal "Worst Case" limits for nominal (operational limits) and maximum (survival limits) for articles exposed to both earth and sky are listed below. These are provided only to lend an appreciation for the possible extreme thermal environment that may be encountered. For example, cloud top temperatures for typhoons can expose the payload to -90°C temperatures for a relatively short period. But the nominal cold extreme is -65°C . Depending upon the terrain over which the balloon is flying, cold limits for any particular night may be warmer than those listed here. Conversely, high albedo during daytime can expose parts of the payload to $+55^{\circ}\text{C}$. But nominal upper limits are $+40^{\circ}\text{C}$ or less. Passive and/or active thermal controls may be required in order to operate under these conditions.

- For articles exposed to external ambient
 - Cold Case Temperatures: Operational down to -65°C (nighttime)
 Survive down to -90°C (2-hour duration)
 - Hot Case Temperatures: Operational up to $+40^{\circ}\text{C}$ (daytime)
 Survive up to $+55^{\circ}\text{C}$ (2-hour duration)
- Unique Cases/Specialty Hardware
 - Photo Voltaics (PV) should operate up to $+75^{\circ}\text{C}$ and survive up to $+90^{\circ}\text{C}$. Higher ratings for photo voltaics are due to the solar orientation and the color/material absorptivity properties. Designs must account for thermal emissions off the backsides of PV cells. Similarly, any other unique material properties have to be evaluated on a per case basis as the above limits are stated only to provide for general planning consideration and not as absolute limits for all cases.

The balloon payload environment is close-coupled with earth albedo. Because of the wide latitude in payload geometry, attitude control, packaging, coatings, modes of operation, and various thermal control options, balloon payload designs must be tailored based upon each mission's requirements and constraints. For approved balloon missions, the NASA balloon program can assist with providing environmental data, for a particular flight scenario, for use in thermal analysis.

10.0 Materials

Same as noted in the Geospace MAR.

11.0 Contamination

Same as noted in the Geospace MAR.

12.0 GIDEP Alerts and Problem Advisories

Same as noted in the Geospace MAR.

13.0 Risk Management Requirements

Same as noted in the Geospace MAR.

END OF DOCUMENT